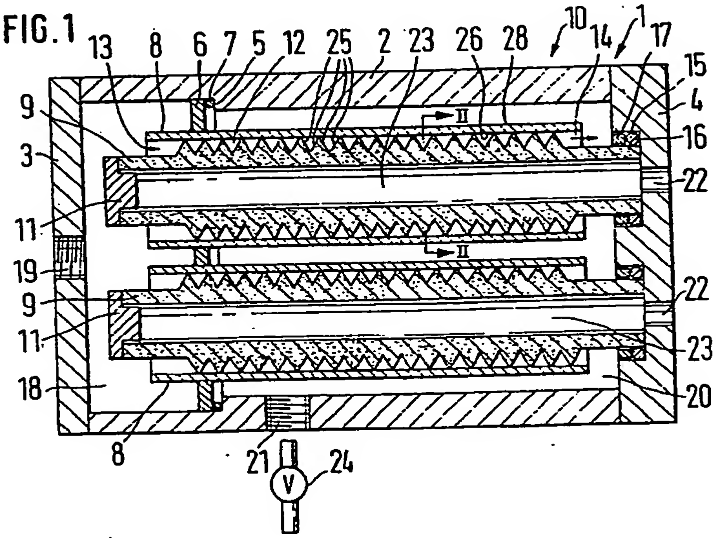
EP34697 ①

(12) UK Patent Application (19) GB (11) 2 011 796 A

(21) Application No 7848783
(22) Date of filing 15 Dec 1978
(23) Claims filed 15 Dec 1978
(30) Priority data
(31) 2800425
(32) 5 Jan 1978
(31) 2848631
(32) 9 Nov 1978
(33) Fed. Rep. of Germany (DE)
(43) Application published 18 Jul 1979
(51) INT CL[2] B01D 29/34 13/00 35/22
(52) Domestic classification B1D 1513 1801 1802 1804 1805 1806 1811 1905 2001 2005 2106 2113 2304 2305 2308 LA B1X 6B6 6F1 6J6 6L4
(56) Documents cited GB 1308440 GB 1183426 GB 796448
(58) Field of search B1D B1X
(71) Applicant
Edward Kusters, Gustav-Funders-Weg 18 4150 Krefeld, Federal Republic of Germany
(72) Inventors
Valentine Appenzeller, Christopher Walter Aurich, Johannes Kutz, Werner Hartmann
(74) Agent
Forrester, Ketley & Co.

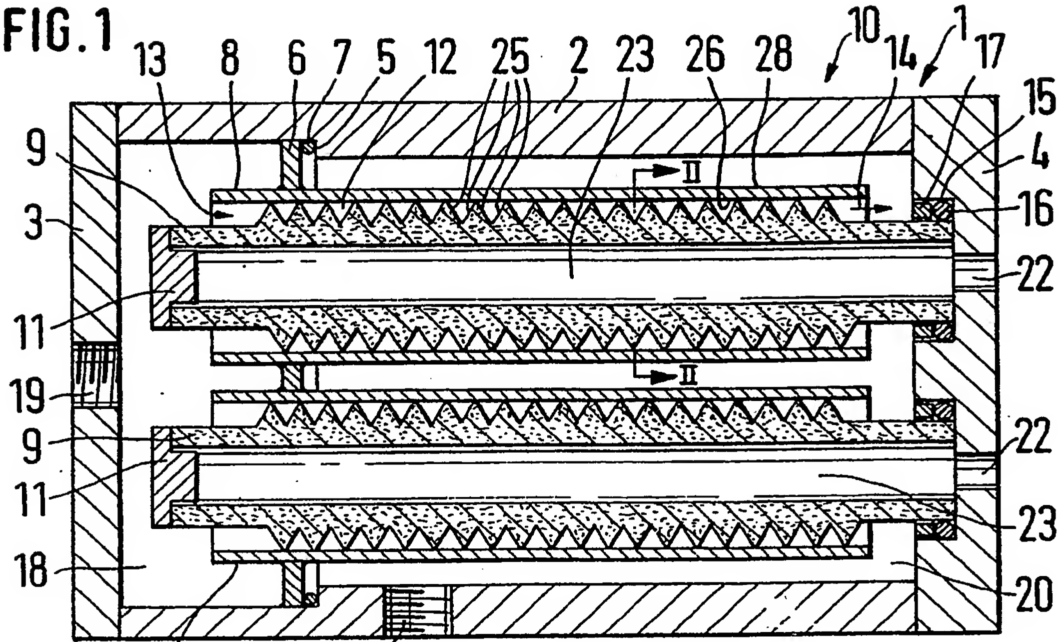
(54) **Grooved Filter Elements**

(57) A tubular filter element 9 is continuously cleaned during filtration by causing the incoming liquid (e.g. textile processing waste water or salt water for reverse osmosis separation) to pass along groove(s) 12 formed in the inlet surface of the filter element, the groove(s) extending axially, helically or tortuously and being closed in the radial direction either by a tube 8 or by similarly grooved, adjacent, filter elements. A plurality of such encased grooved filter elements are contained in a housing 1, unfiltered liquid with its entrained solids leaving through outlet 21 having a pressure controlling valve 24 and filtrate being withdrawn from outlets 22. The tubular element either acts directly as a filter element or as a support for a filter coating thereon, the element being of porous plastics, ceramic, graphite or sintered steel. The grooves are triangular, rounded or rectangular in cross-section and the tubular element may be hexagonal, triangular or square in cross section.

FIG.1



GB 2 011 796 A

FIG.1



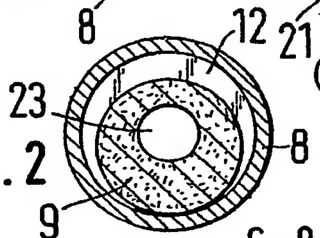




FIG. 2

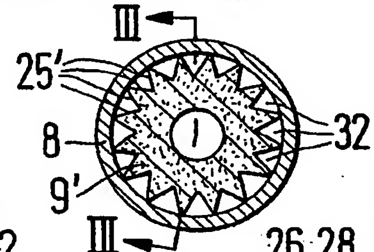
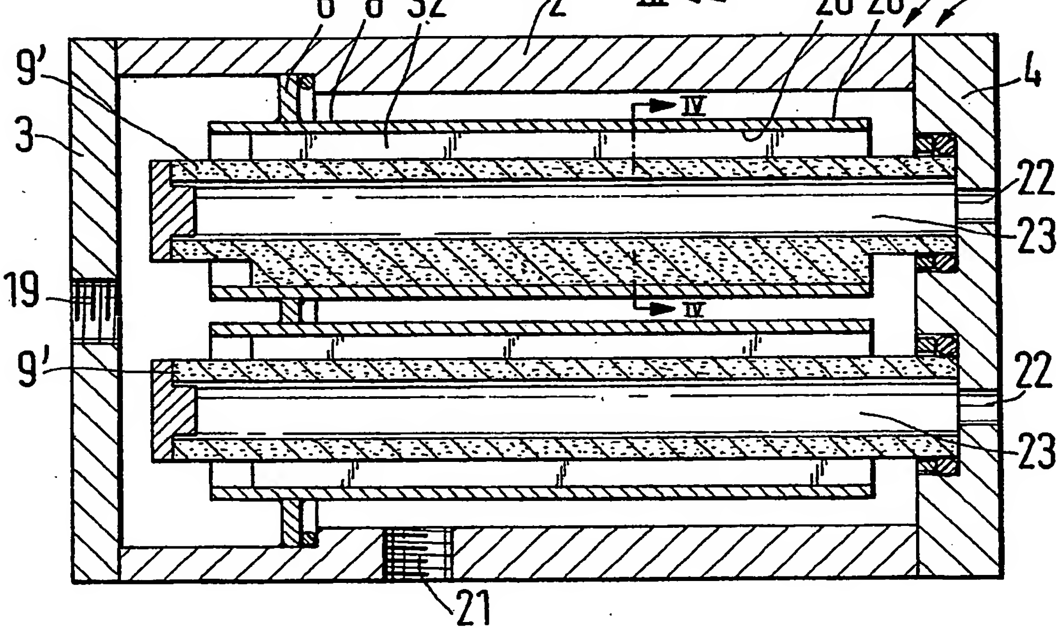



FIG. 4

FIG.3



2/3

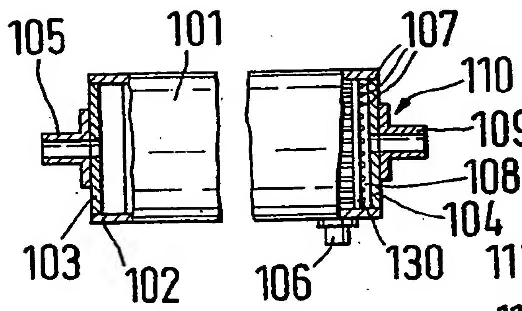



FIG. 5

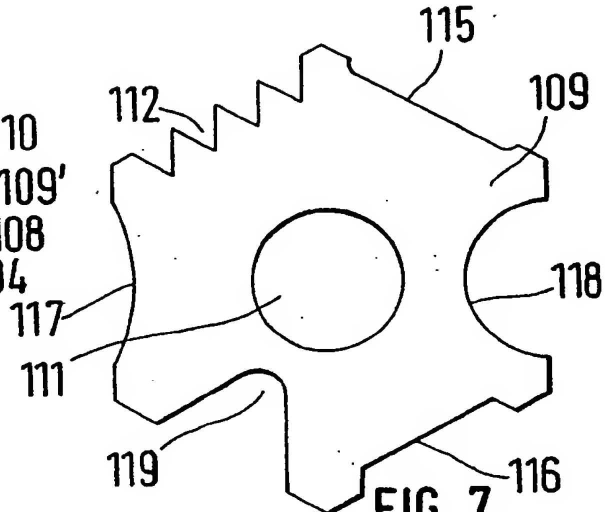
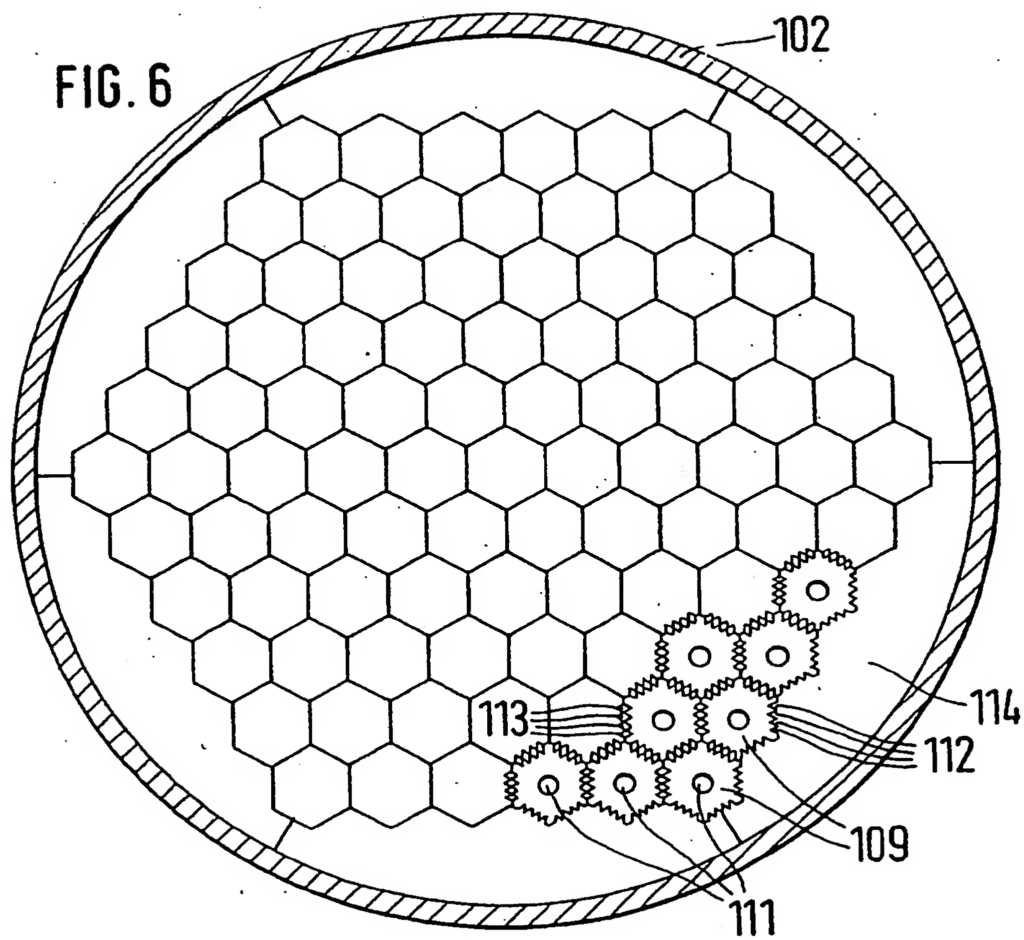



FIG. 7

FIG. 6



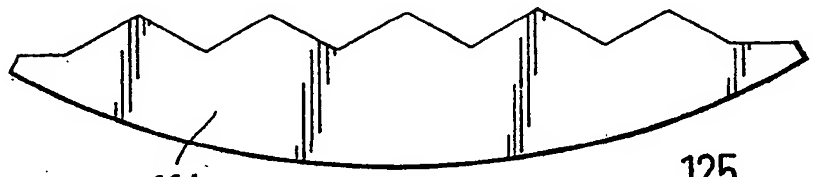



FIG. 8

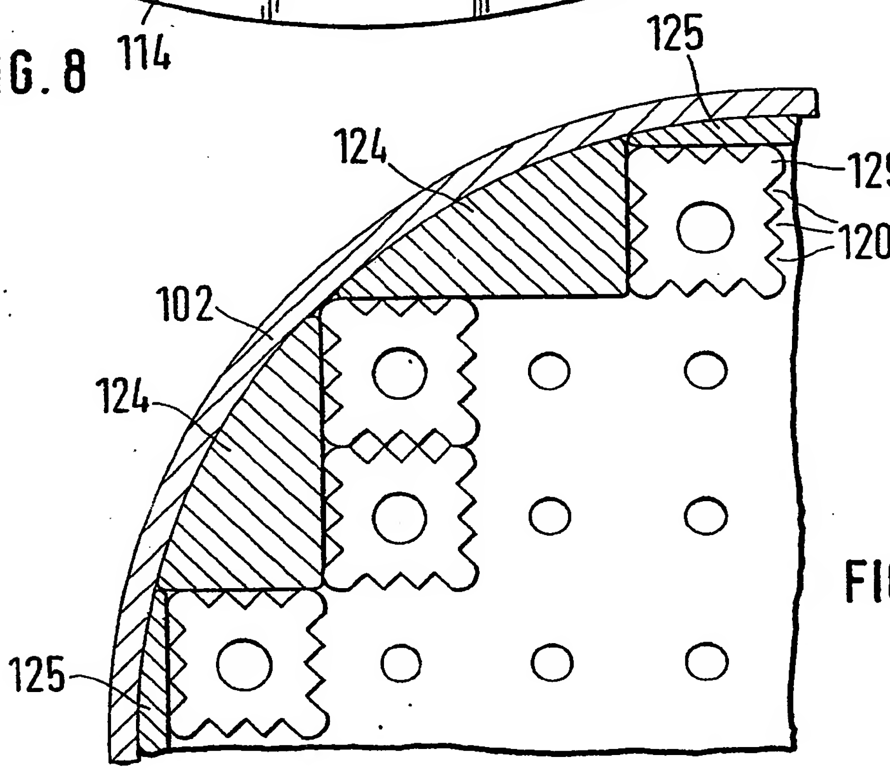



FIG. 9

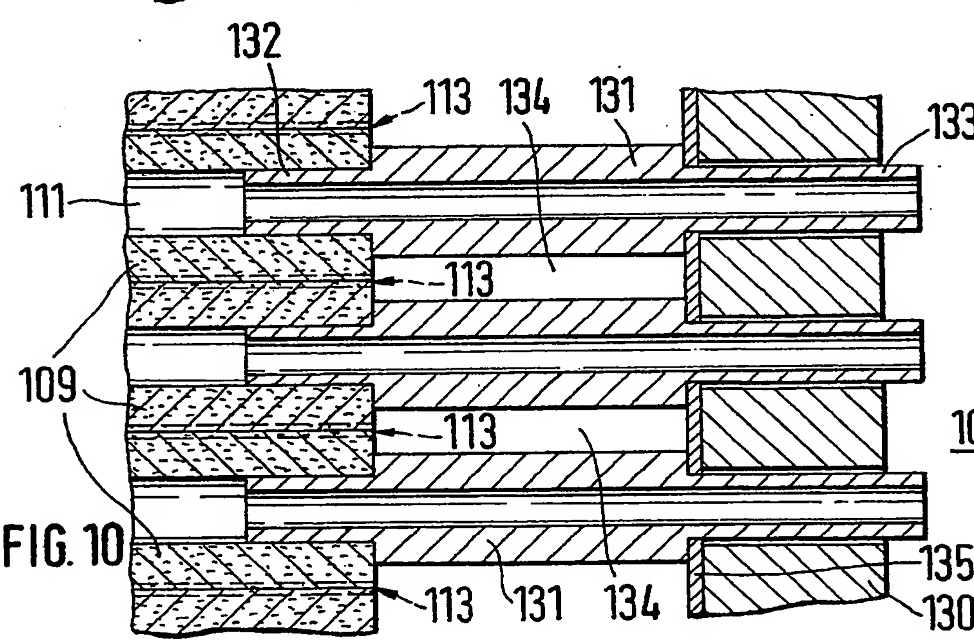



FIG. 10

SPECIFICATION
**Improvements in or Relating to a Filter**

This invention relates to a filter and more particularly to a filter system comprising at least one tubular filter element with porous walls, through which the liquid passes substantially radially, particles above a specific size being retained at the upstream surface of the wall.

Tubular filter elements of this kind consisting of porous plastics, ceramic material, metal, graphite, etc are known. They are used either directly as filter elements or as a support for a filter material applied in a liquid phase at the upstream surface of the filter element, to form a solid coating of the filter material. Such diaphragms enable very fine filtration to be carried out. Mixtures of solvents and dissolved particles can be separated by diaphragm filtration. The separated particles are retained on the surface of the diaphragm.

If the solvent and the dissolved components of the solution for filtration have substantially the same molecular sizes, as is the case, for example, with common salt and water, the separation is referred to as "reverse osmosis". since separation takes place in opposition to the osmotic pressure, the pressure on the solution side must be in excess of the osmotic pressure if filtration is to be achieved. The pressures required may be considerable; for example, a 10% common salt solution has an osmotic pressure of 80 bar, and this must be overcome.

When the sizes of the molecules differ from one another considerably, then "ultrafiltration" is involved. This is used for concentration, fractionation or the purification of macromolecular solutions. Since the dissolved components may have a high molecular weight in comparison with the solvent, generally more than 2000, the solution have only a low osmotic pressure, and therefore separation in these cases can be carried out at relatively low pressures, e.g. 1 to 10 atmospheres.

The particles which are to be separated are retained on the upstream surface of the diaphragm. If the liquid for filtration remains, for example, substantially stationary against the entry surface, and if no special steps are taken to discharge the accumulated particles a layer of separated particles forms during operation of the filter and reduces the permeability of the filter system or increases the operating pressure required. Thus the layer of separated particles forming during filtration is preferably removed from such a filter system at regular intervals.

The present invention seeks to provide a filter system of the above described type which can be operated continuously at constant pressures.

According to this invention there is provided a filter system comprising at least one tubular filter element with porous walls, through which the liquid passes substantially radially, particles above a specific size being prevented from entering at the entry surface through which the liquid enters the filter element wherein at least one externally closed groove forming a flow path leading from an inlet for liquid to be filtered to an outlet for said liquid after liquid has been filtered therefrom is provided in the said entry surface of the tubular filter element.

It is believed that the provision of the groove or grooves leads to two effects.

First of all, there is a flow path along the surface, through which the total quantity of the liquid for filtration must pass, the flow cross-sections being relatively narrow. In these conditions the liquid for filtration experiences good contact with the entry surface formed by the walls of the grooves. The liquid for is in movement everywhere relatively to the entry surface, so that particles retained on the entry surface after separation from the filtrate by the filter element material are immediately rinsed away and remain in suspension or in solution in the concentrate. This effect can be assisted if the grooves are so devised that the flow is as turbulent as possible in order to prevent the formation of laminar boundary layers with practically stationary zones near the wall at the entry surface. It is therefore impossible for parts of the entry surface to form what are known as "dead" zones, in which separated particles accumulate to form a layer because they are not removed or discharged, and it is also impossible for appreciable quantities of the liquid to pass through the filter without contacting the entry surface, because a large quantity of the liquid remains in the interior of large cross-section stream of liquid.

The other effect of the grooves is believed to be that the entry surface of an otherwise identical filter element in respect of its external dimensions is increased with respect to a purely cylindrical entry surface. This is important particularly when the actual filter element bears a filter diaphragm on the entry surface. As a result the throughput is increased for a fixed input pressure. The surface area may be increased by a factor of 2 to 3.

The entry surface can theoretically be either the inner surface or the outer surface of the tubular filter element. In the preferred embodiment, however, the outside is constructed as a grooved entry surface. This is done primarily for practical reasons because it is easier way of forming the grooves on the outside of a tubular filter element and because there is a larger surface available on the outside of a tubular element. A more important reason for this preference, however, is that the sintered materials or other porous materials used for the filter elements can take much higher compressive stresses than tensile stresses. Given identical pressures, therefore, a filter element may have thinner walls when the pressure is applied from outside. Consequently, the flow resistance falls and so does the power required to process each unit volume of filtrate.

The grooves may extend axially, helically or may follow a tortuous path on the tubular filter element. The said closed surface may be formed by the wall of a tube which, in the case of grooves

formed on the outside of the tubular filter elements, encloses the latter and engages with them. In that case, therefore, it is formed by an external part separate from the filter element.

Since the liquid for filtration may, in some cases, have to be put under considerable pressure to force the filtrate through the pores of the diaphragm or filter element, the tube containing the filter element is advantageously located in a pressure housing or casing in which the concentrate pressure i.e. the pressure of the liquid from which liquid has been filtered acts on the free peripheral surface of the tube.

In this way, the tube is not subjected to a great pressure if the concentrate is also pressurized. The tube structure can be made lighter in such cases, because it then has to withstand only the differential pressure between the entry pressure and the counter-pressure of the concentrate. This differential pressure can be selected by appropriate adjustment of the counter-pressure. It is only required to be at least equal to that necessary to convey the liquid for filtration through the grooves in the filter element. While the entry pressure to be accommodated by the pressure housing may be in the order of magnitude of 100 bar in a practical construction, only values of a few bar remain for the differential pressure to be taken by the tube. Enclosing the filter elements in a tube also has the object of covering the high-pressure grooves with an element which can itself be exposed to a pressure liquid such as the concentrate and is thus relieved of any stress arising from the high pressure.

In one practical embodiment of the invention the inlet for liquid to be filtered is situated at one end, and the outlet for liquid from which liquid has been filtered is situated at the other end of the tube, a pressure-tight partition is provided in the pressure housing or casing and is sealed to the pressure housing or casing and the tube and divides the pressure housing or casing into a first chamber and a second chamber, the said inlet to the filter element and also the inlet to the housing communicate with the first chamber and the said outlet of the filter element, and the discharge outlet of the housing for liquid which has been filtered communicate with the second chamber.

As a result of the pressure-tight partition, the liquid for filtration cannot immediately pass from the pressure housing inlet to the outlet, but is forced to cover the distance along the filter elements from their inlet to their outlet.

The pressure housing discharge outlet may be followed by a pressure control valve to produce the aforesaid counter-pressure, which partially relieves the tube of pressure and is also intended to influence the filtration operation.

As described above, the "closed surface" resulting in the forced-flow path may be formed by the periphery of a tube which surrounds and engages with the tubular filter element. Parts in addition to the filter element are required in these conditions to form the forced-flow paths. In addition, the areas left between the tubes constitute considerable loss cross-sections.

To reduce the outlay for forming the "closed surface" of the grooves and avoid loss cross-sections, according to an important aspect of the invention the grooves may be closed by the surface of an adjacent tubular filter element.

The adjacent filter elements are thus situated side by side and themselves define the forced-flow paths, so that no additional limiting elements are required.

Advantageously, the cross-section of the filter elements complement one another so that a plurality of filter elements form an assembly having an overall cross-section which is tightly packed and has the liquid flow passages defined by the grooves.

The filter elements thus form a compact set, in the cross-section of which only the inside cross-section of the filter elements and the passages left at their surface by the grooves are free.

To this end, the filter elements may have a regular polygonal cross-section to enable the elements to be packed tightly.

This means that the filter elements may be packed together to form a larger cross-section without leaving any intermediate spaces. Cross-sections in the form of an equilateral triangle, a square, or an equilateral hexagon are thus possible. A pentagonal cross-section is not preferred, however.

The embodiment with a hexagonal cross-section is generally preferred because it is fairly close to a circular cross-section and the paths to be covered by the liquid through the filter element material until it reaches the inner wall are of a similar length on entry from every point of the outer periphery.

Conveniently, the tubular filter elements together are disposed in a tubular housing and the residual cross-sectional areas of which cannot be filled by the filter elements are filled by filling elements of appropriate shape.

Preferably the tubular filter elements are disposed in a housing having two end caps and the tubular filter elements being closed at one end, and, at the other end, tubular members being provided which produce a sealing-tight connection between the interior of the tubular filter elements and the outside of the end piece.

In order that the invention may be more readily understood and so that further features thereof may be appreciated the invention will now be described by way of example with reference to the accompanying drawings, in which:

Figure 1 is a longitudinal section through a module containing a plurality of filter elements;

Figure 2 is a cross-section on the line II—II in Figure 1 through a single filter element;

Figure 3 is a longitudinal section similar to Figure 1, of an alternative embodiment on the line III—III in Figure 4;

Figure 4 is a cross-section on the line IV—IV in Figure 3;

Figure 5 is a side elevational view, partly cut

away of another filter system according to the invention;

Figure 6 is a cross-section through the filter system shown in Figure 5 to an enlarged scale;

Figure 7 is a diagrammatic cross-section through a single tubular filter element illustrating different groove cross-sections, again to an enlarged scale;

Figure 8 is a cross-section through a space filling element used in the embodiment of Figures 6 and 7;

Figure 9 is a sectional view of part of another embodiment of the invention in which the tubular filter elements have a substantially square cross-section; and

Figure 10 shows the connection of the filter elements of Figure 5 on the outlet side.

The filter system 10 shown in Figure 1 comprises a pressure resistance casing having the general reference 1 and consisting of a tubular part 2 with covers 3 and 4 fitted to the ends so as to be pressure-tight. The tubular part 2 has an inner shoulder 5 against which a circular partition 6 bears axially there being an annular seal 7 between the shoulder 5 and partition 6. The partition 6 extends across the entire cross-section of the tubular part 2 of the casing. The partition 6 has cutouts in which tubes 8, which are parallel to the tube axis, are disposed in sealing-tight relationship, two such tubes being shown in Figure 1. The arrangement of the tubes 8 within the cross-section of the casing 1 is such that substantially the maximum number of tubes 8 can be accommodated within the space available.

Cylindrical filter elements 9 are disposed within the tubes 8, the outer periphery of each element 9 engaging the inner periphery 26 of the respective tubes 8. The outer peripheral surface of each element 9 is the entry peripheral surface, that is to say the upstream surface, or the surface that the solution to be filtered first encounters during the filtration process. The filter elements 9 are themselves tubular and each element 9 is closed by, plug 11 at the end adjacent the cover 3. On its outer cylindrical surface each element 9 has a helical groove 12, which forms a helical passage for the flow of liquid between the filter element 9 and the inner surface of the tube 8, the liquid to be filtered entering such passage at the inlet 13 shown on the left in Figure 1, and leaving it at outlet 14 shown at the right-hand side of Figure 1. The walls of the groove 12 form the entry surface 25, or the surface through which the liquid to be filtered enters the filter element. At the right hand end as shown in Figure 1 the filter element 9 projects beyond the end of the tube 8 and is sealed by means of an annular seal 16 located in a corresponding recess 15 in the right-hand cover 4, said seal being pressed into the recess by a collar 17.

The partition 6 divides the interior of the casing 1 into a first chamber 18, which is situated on the left in Figure 1 and into which the inlet 19 of the casing 1 leads. The right hand chamber 20 in Figure 1 communicates with the concentrate outlet 21 of the casing. The interior 23 of the tubular filter elements 9 communicates with the exterior of the casing 1 via outlets 22 in the cover 4.

When the filter assembly is operating the pressure in the chamber 20 is practically the same as in the chamber 18 and in the groove 12. Since this pressure is operative both on the inner surface 26 of the tubes 8 and on their exposed outer peripheral surface 28, the tubes 28 are subjected to substantially no pressure loading and can be accordingly of light weight.

The filter system 10 operates as follows: The liquid for filtration flows through the inlet 19 of the pressure housing 1 into the chamber 18 and then via the inlet 13 into the helical groove 12, the liquid moves helically therein along the filter element 9, and leaves the outlet 14 of the groove to enter the chamber 20, from which it emerges as a concentrate from outlet 21 of pressure housing 1. The pressure in the chambers 18, 20 can be controlled by the pressure control valve 24.

During its passage through the helical groove 12, some of the liquid for filtration enters the interior of the filter element 9 and in so doing leaves suspended and/or dissolved particles on the entry surface 25 formed by the outer periphery of the filter element 9, or by a coating applied to the filter element, but these particles do not lodge there but are immediately entrained by the passing liquid, i.e. they remain in the moving concentrate. After passing through the wall of the filter element 9, the filtrate enters the interior 23 of the filter element and can be withdrawn at the outlets 22. The concentrate is returned to the inlet 19 and recycled, if desired after entrained substances have been separated and after it has been combined with new liquid for filtration. In this way there is a continuous separation of the filtrate, e.g. pure water from waste water.

The embodiment of the invention shown in Figures 3 and 4 differs from that shown in Figures 1 and 2 only in respect of the construction of the filter elements 9, the outside of which has peripherally distributed axial grooves 32 of substantially triangular cross-section instead of a helical groove of triangular cross-section as in the previous embodiment. The axial grooves 23 may alternatively be replaced by grooves having a slight pitch, since this may improve the contact between the liquid for filtration and the entry surface 25′ of the filter element 9′. Otherwise the construction and operation of the embodiment shown in Figures 3 and 4 corresponds to that shown in Figures 1 and 2.

The triangular cross-sectional shape of the grooves in the embodiments illustrated in Figures 1 to 4 is not essential. Rounded or more rectangular cross-section may alternatively be used for the grooves.

The filter system 110 shown in Figure 5 comprises a pressure housing having the general reference 101, and consisting of a tube 102 of corrosion-resistant steel having, for example, an

inside diameter of 220 mm and a wall thickness of about 8 mm. The tube 102 is closed so as to be pressure-tight by means of end members 103, 104 in the form of covers. The liquid for filtration is supplied at the connection 105 at high pressure e.g. 70 bar and emerges from connection 106. The filtrate passes through partitions 107 into the chamber 108 and is withdrawn via the connection 109. Referring to Figure 6, the interior of the tube 102 is filled substantially by a set of individual filter elements 109 which each have an external cross-section in the form of a regular (i.e. equilateral and equiangular) hexagon. The filter elements 109 consist, for example, of porous graphite or porous-sintered tubes of corrosion resistant steel. Together, the filter elements 109 make up a tightly packed assembly the outer periphery of which is in the form of a rectangular hexagon. The assembly is enclosed by the inner periphery of the tube 102. In the illustrated example, 92 filter elements 109 are combined to form the assembly.

The filter elements 109 are tubular and each have an inner passage 111. Each filter element 109 has grooves 112 extending continuously in the longitudinal direction on the exterior or outside surface thereof and so disposed as to be situated exactly opposite the corresponding grooves 112 on the opposite hexagonal side of an adjacent tubular filter element 109. In this way, continuous liquid passages 113 are formed longitudinally and form a forced-flow path for the liquid for filtration introduced under pressure at connection 105.

To ensure that the liquid really passes through the passages 113 and does not take the path of least resistance through the residual cross-section left outside the assembly of tubular filter elements 109, said residual cross-sections are filled by shaped filling elements 114 of appropriate cross-section, one of which is shown separately in Figure 8. The shape filling elements must be able to withstand the pressure of the liquid so that they do not yield to open side paths to the liquid. The filling elements may extend over substantially the entire length of the housing 101 of the filter system 110. In some cases, however, it may be sufficient for them to provide just in a single transverse plane in the form of transverse bulkheads.

The entire interior of the tube 102 on the left of the plate 130, shown in Figure 5, which is in the form of a transverse bulkhead, is subject to the pressure of the liquid for filtration introduced via connection 105. The individual filter elements 109 are thus free of pressure loading on all sides and are not forced apart, for example, by the pressure in the passages 113. The liquid entering at connection 105 thus flows through the passages 113 to the right-hand end with reference to Figure 5, which corresponds to the end of the filter elements 109, as will be seen from Figure 10. This end of each filter element 109 terminates at a distance from the plate 130, and this distance is bridged by the tubular members 131. The members 31 each engage by a projection 132 into the passage 111 of the filter elements 109 and also engage by a projection 133 at the other end with apertures formed in the plate 130. In this way the passages 111 are connected in sealing-tight relationship to the chamber 108 which is situated on the right of the plate 130 in Figures 5 and 10. The filtrate is withdrawn from chamber 108 in a practically pressureless state, or at a slight pressure, through the connection 109.

The liquid for filtration flowing from the ends of the passages 113 and entering the space left between the individual tubular members 131 between the ends of the filter members 109 and the plate 130 is discharged through the connection 106 and re-cycled.

The side of the plate 130 adjacent the space 134 is clad (135) with corrosion-resistant steel.

Figure 7 shows, in one figure, six alternative possibilities for the configuration of the cross-section of the grooves at the surface of the filter elements 109. Of course, in practice, the same grooves cross-section may be provided on all six sides of the filter element 109.

The grooves 112, which are illustrated in Figure 6, have an equilateral triangular cross-section with the apex inwards, i.e. with the apex towards the passage 111 in the filter element 109. In the illustrated embodiment four grooves 112 are provided on each side of the hexagon.

The selection of the groove cross-section must be a compromise between different requirements. Of course the maximum possible entry surface is required for the filter element 109 but at the same time the cross-section of the passages 113 formed by the grooves must be so large as to give a reasonable flow velocity and avoid the deposition of filter residues and the like on the groove walls. A triangular cross-sectional shape of the grooves 112 appears to be a satisfactory compromise, particularly because the entry surface is not too far away from the inner passages 111 and hence the liquid entry can be expected to be fairly uniform. The grooves 112 are also fairly easy to produce because of their shallow depth.

The grooves 115 which have a planar bottom, and upwardly curving side walls, i.e. a flat rectangular cross section, the long side of which is parallel to the surface of the filter element in which the groove is formed, are not so favourable, because the available entry surface and resulting passage cross-section are small. In the case of groove 116, which has a similar shape to that of groove 115, but which has planar upwardly angled side walls, although the passage cross-section is more favourable, there is still on a small entry surface.

The slightly curved cross-section of the groove 117 poses substantially the same disadvantages in use as the groove 115. Although the grooves 118 of deep semicircular section and 119 of deep triangular section with a curved apex give relatively large entry surfaces, the passage cross-

section are too large so that the proportions of liquid flowing in the middle of the passage have practically no opportunity of coming into contact with the passage wall. In particular, the distances between the individual points of the entry surface and the wall of the passage 111 differ considerably.

Referring to Figure 9 in yet another embodiment of the invention, the tubular filter elements 129 have a substantially square outside cross-section and have three grooves 120 of triangular cross-section with the apex pointing inwards on each side of the square. The radial cross-section remaining at the outer periphery of the set filter elements 129 in relation to the inner periphery of the tube 102 are filled by shape filling elements 124, 125 of appropriate cross-section.

The exact construction of the filter material is unimportant. The filter elements may be porous filter elements which separate the particles from the liquid by means of the pores therein, or else they may be filter elements in which a cohesive coating, which is a filter diaphragm and constitutes the actual filter layer, is deposited at the entry surface on a porous element acting as a support. Diaphragm of this kind can be used to separate particles down to the size of molecules dissolved in the liquid for filtration.

An important application of the filter system is to purify textile processing waste water to eliminate chemicals such as paste and the like, which have molecules of considerable size. In that case the filter elements may consist of graphite or sintered tubes of corrosion-resistant steel. They may have a diameter of 15 to 25 mm and may be combined to form an assembly in a common pressure housing, the assembly comprising between 30 and 100 filter tubes.

It is to be appreciated that the drawings accompanying this Specification are primarily diagrammatic.

In further embodiments of the invention, not illustrated, the grooves may each follow a tortuous path over the surface of the filter element.

## Claims

1. A filter system comprising at least one tubular filter element with porous walls, through which the liquid passes substantially radially, particles above a specific size being prevented from entering the filter element at the entry surface through which the liquid enters the filter element wherein at least one externally closed groove forming a flow path leading from an inlet for liquid to be filtered to an outlet for said liquid after liquid has been filtered therefrom is provided in the said entry surface of the tubular filter element.

2. A filter system according to claim 1 wherein said entry surface is the outer peripheral surface of said filter element.

3. A filter system according to claim 2, wherein the grooves are closed by a cylindrical closed surface engaging in sealing-tight relationship against the peripheral surface of the tubular filter element.

4. A filter system according to any one of claims 1 to 3 wherein said closed surface is formed by the wall of a tube.

5. A filter system according to any one of the preceding claims wherein the grooves extend substantially axially of the tubular filter element.

6. A filter system according to any one of claims 1 to 4 wherein the grooves extend helically on the tubular filter element.

7. A filter system according to any one of claims 1 to 4 wherein the grooves follow a tortuous path over the tubular filter element.

8. A filter element according to claim 4 or any claim dependent thereon wherein the tube with the filter element is disposed in a pressure housing or casing in which the pressure of liquid from which liquid has been filtered acts on the free peripheral surface of the tube.

9. A filter system according to claim 8, wherein the inlet for liquid to be filtered is situated at one end, and the outlet for liquid from which liquid has been filtered is situated at the other end of the tube, a pressure-tight partition is provided in the pressure housing or casing and is sealed to the pressure housing or casing and the tube and divides the pressure housing or casing into a first chamber and a second chamber, the said inlet to the filter element and also the inlet to the housing communicate with the first chamber and the said outlet of the filter element, and the discharge outlet of the housing for liquid which has been filtered communicate with the second chamber.

10. A filter system according to claim 9, wherein the discharge outlet is connected to a pressure control valve.

11. A filter system according to any one of claims 1 to 3 or any one of claims 5 to 7 dependent thereon wherein the grooves are closed by the surface of an adjacent tubular filter element.

12. A filter system according to claim 11, wherein the cross-section of the filter elements complement one another so that a plurality of filter elements form an assembly having an overall cross-section which is tightly packed and has the liquid flow passages defined by the grooves.

13. A filter system according to claim 12, wherein the filter elements, each have a regular polygonal cross-section.

14. A filter system according to claim 13, wherein the filter elements have an equilateral and equiangular hexagonal cross-section.

15. A filter system according to any one of claims 11 to 14, wherein the grooves of the adjacent filter elements are located with the open sides thereof situated opposite one another.

16. A filter system according to any one of claims 11 to 15, wherein a plurality of grooves are disposed side by side on each side face of the filter element.

17. A filter system according to any one of claims 11 to 16, wherein each groove has a cross-section which is curved into the depth of

the side face of the filter element.

18. A filter system according to any one of claims 11 to 16, wherein each groove has a flat rectangular cross-section, the long side of which is parallel to the side of the polygon.

19. A filter system according to any one of claims 11 to 16, wherein each groove has a triangular cross-section with the apex pointing to the centre of the filter element.

20. A filter system according to any one of claims 11 to 19, wherein the tubular filter elements together are disposed in a tubular housing and the residual cross-sectional areas of which cannot be filled by the filter elements are filled by filling elements of appropriate shape.

21. A filter system according to any one of claims 11 to 20, wherein the tubular filter elements are disposed in a housing having two end caps, and the tubular filter elements being closed at one end and at the other end, tubular members being provided which produce a sealing-tight connection between the interior of the tubular filter elements and the outside of the end piece.

22. A filter system substantially as herein described with reference to and as shown in Figures 1 and 2 of the accompanying drawings.

23. A filter system substantially as herein described with reference to and as shown in Figures 3 and 4 of the accompanying drawings.

24. A filter system substantially as herein described with reference to and as shown in Figures 5 to 8 and 10 of the accompanying drawings.

25. A filter system substantially as herein described with reference to and as shown in Figure 9 of the accompanying drawings.

26. A method of filtering comprising the step of utilizing a filter according to any one of the preceding claims.

27. A product made by a method according to claim 26.

28. Any novel feature or combination of features disclosed herein.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1979. Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.